Feasibility study for measuring Drell-Yan cross section and double-spin asymmetry at PHENIX using the FVTX Tracker

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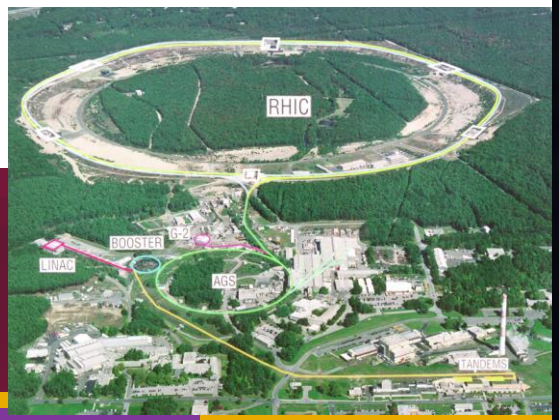
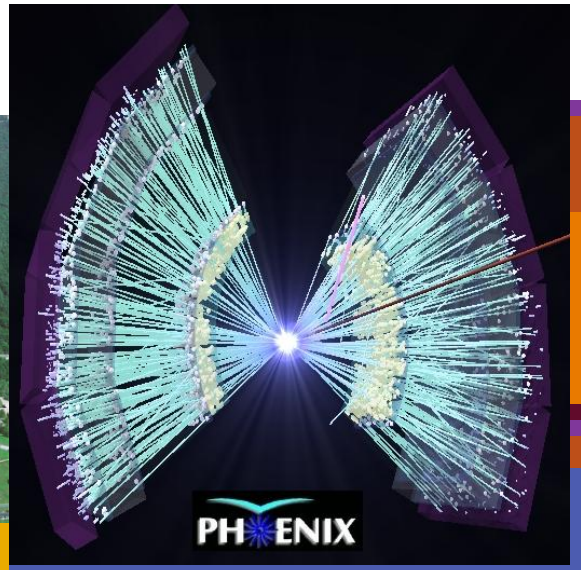


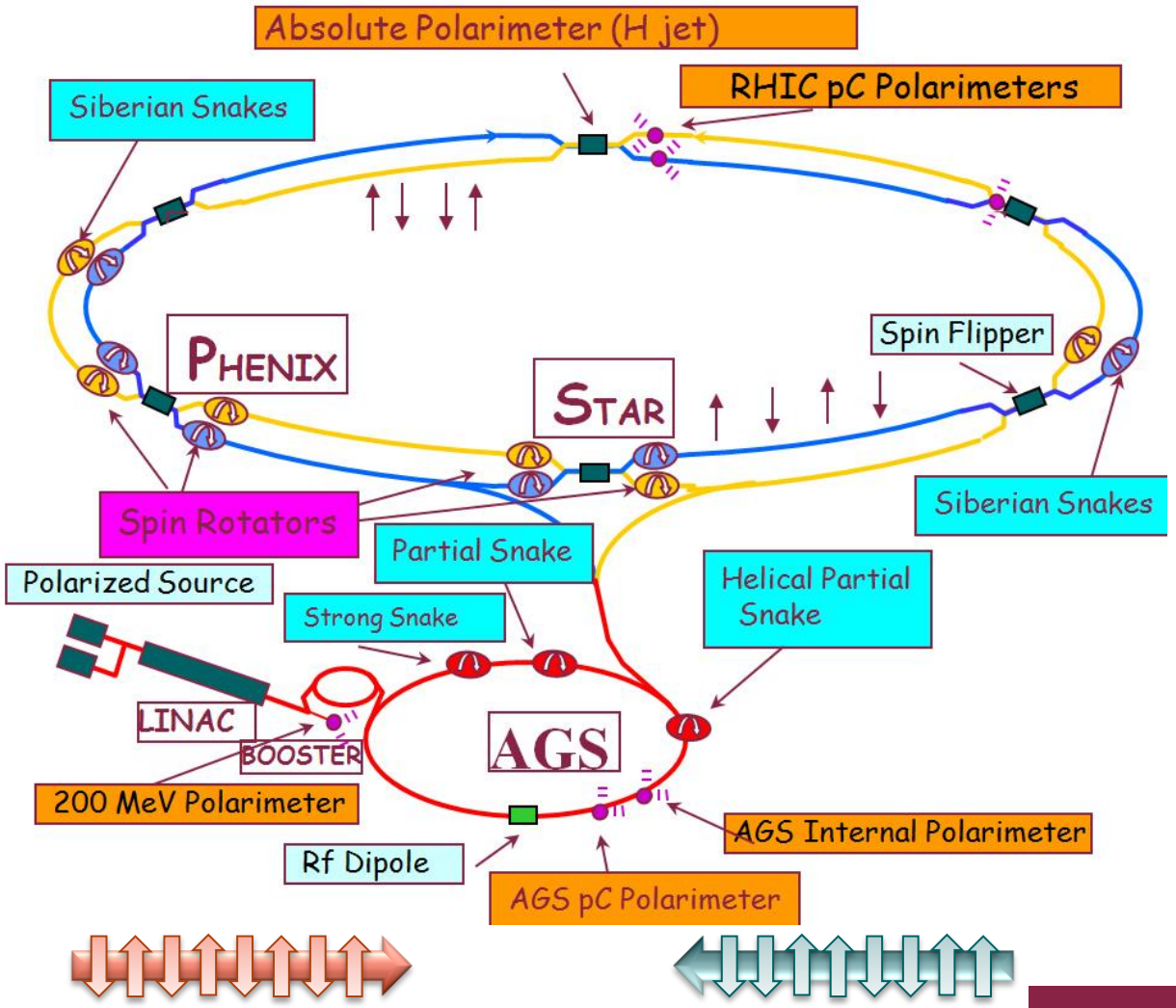


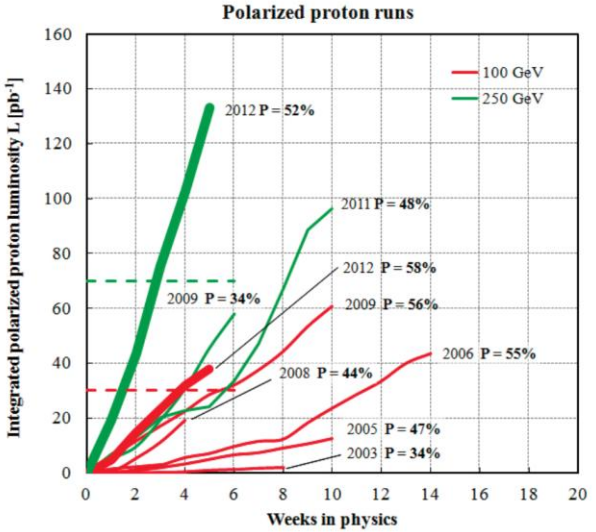
APS April Meeting

14th April 2013 Denver, CO

NM STATE

RHIC as a Polarized p + p Collider





Run 12 Luminosity

- Wide vertex : 49.56 pb^{-1}
- 30 cm vertex : 30.03 pb^{-1}
- 15 cm vertex : 14.81 pb^{-1}

Run 12 Average Proton Polarization

- 52%

Run 13 Luminosity to date

- Wide vertex : 52.74 pb^{-1}
- 30 cm vertex :33.67 pb^{-1}
- 15 cm vertex : 16.92 pb^{-1}

PHENIX

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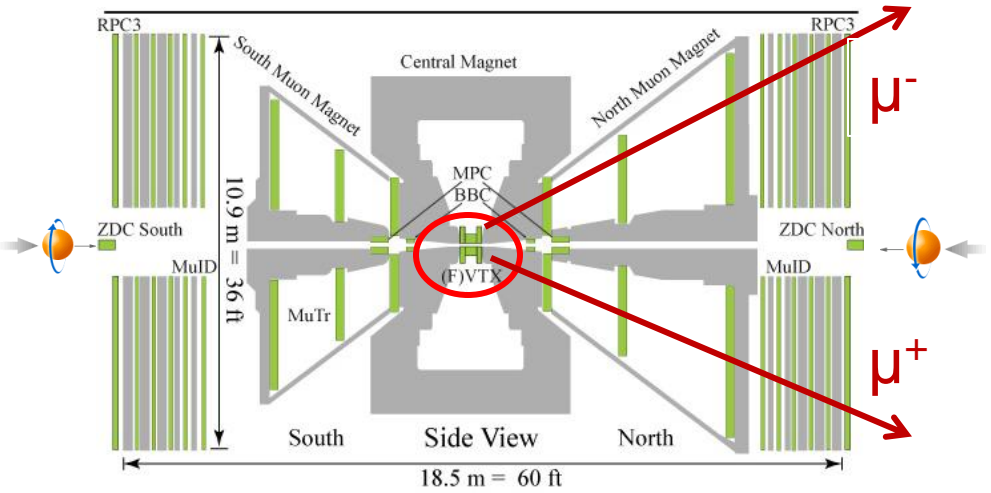
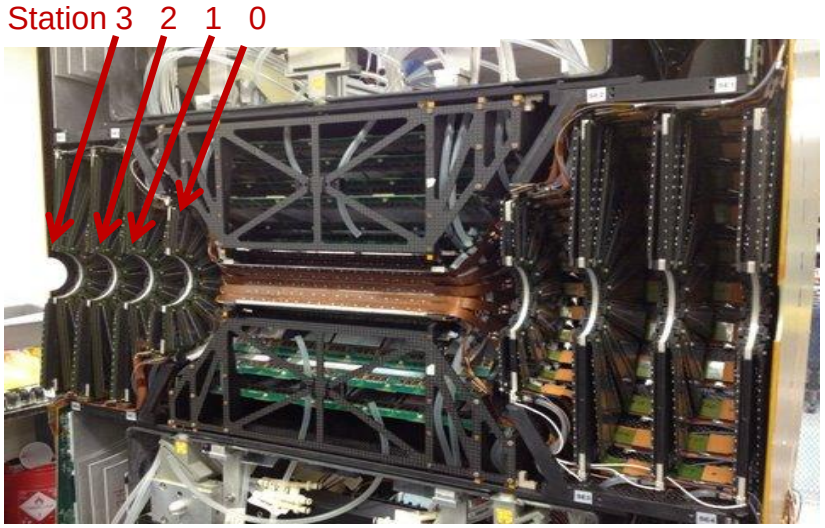
PHENIX Detectors



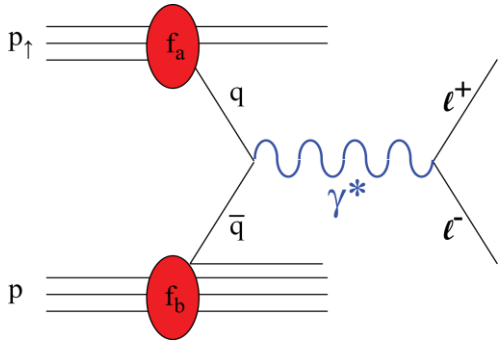


- **Hadrons, photons and electrons in central arms**
  - Drift and Pad chambers for charged particle tracking.
  - Ring Imaging Cerenkov and electromagnetic calorimeter for electron ID
  - VTX for central tracking
- **Muons and Hadrons in the forward regions**
  - Mu ID
  - Mu Trackers
  - RPC
  - FVTX

- **FVTX for forward tracking**
  - 4 planes per end-cap
  - Coverage
    - $1.2 < |\eta| < 2.4$
    - 2π in φ
    - $|z| < 15$ cm
  - Resolution
    - Hit < 25μm
    - DCA_R < 200 μm

Motivation

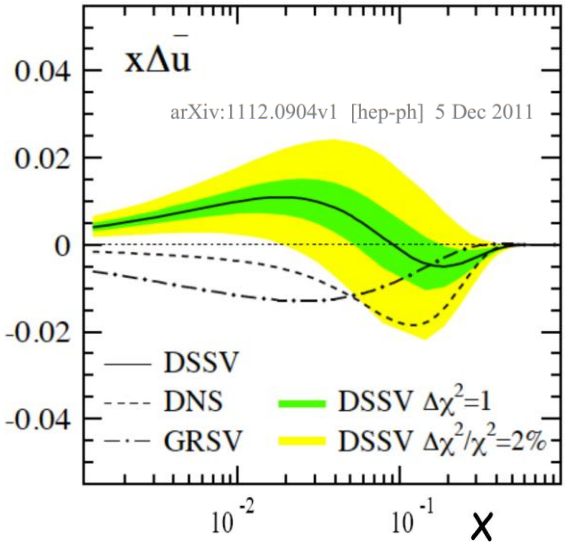
- **Di- muon production in polarized p-p collisions provides unique access to nucleon structures through spin asymmetry measurements**



$$A_{LL}^{DY} = -\frac{\sum_q e_q^2\{\Delta q(x_1)\Delta\bar{q}(x_2) + \Delta\bar{q}(x_1)\Delta q(x_2)\}}{\sum_q e_q^2\{q(x_1)\bar{q}(x_2) + \bar{q}(x_1)q(x_2)\}}$$

$$\approx -\frac{\Delta u(x_1)}{u(x_1)} \cdot \frac{\Delta\bar{u}(x_2)}{\bar{u}(x_2)}$$

u-quark dominates in p+p

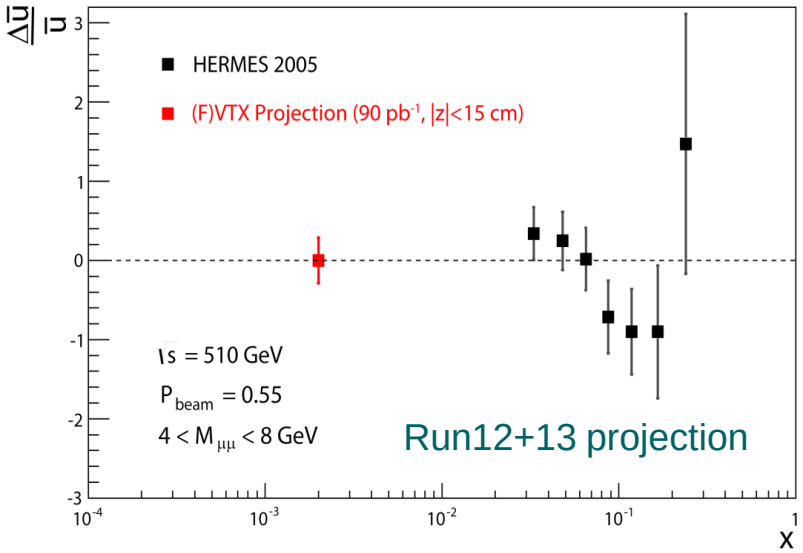


- **Drell-Yan A_{LL} can cleanly access Δ ū / ū which gives the anti-quark helicity distributions in the nucleon sea**

- **No fragmentation process is involved when comparing with previous DIS measurements**

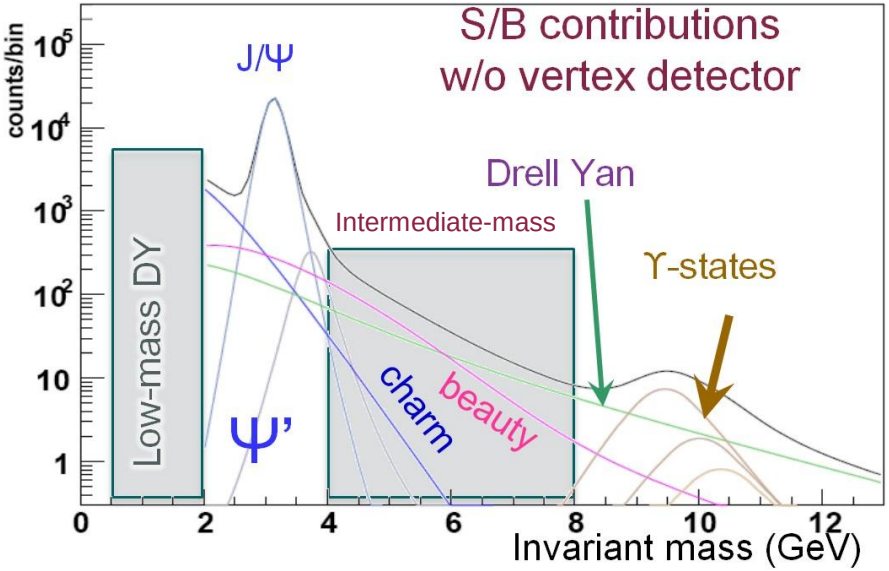
Motivation Cont…

- PHENIX experiment provides powerful detection for di-muon in the forward region (1.2<|η|<2.4) through Muon Trackers
- For di-muons detected in same arm x_1=0.02-0.06, $x_2 = 5 \times 10^{-4}$-2×10^{-3}
- New vertex detector (FVTX) of matching η - acceptance with Muon Trackers provides new capability in differentiating signal to background
- Run 12 and Run 13 data will provide sufficient statistics for Drell-Yan analysis
- If anti-quarks carry no spin we expect Drell – Yan A_{LL} to be zero

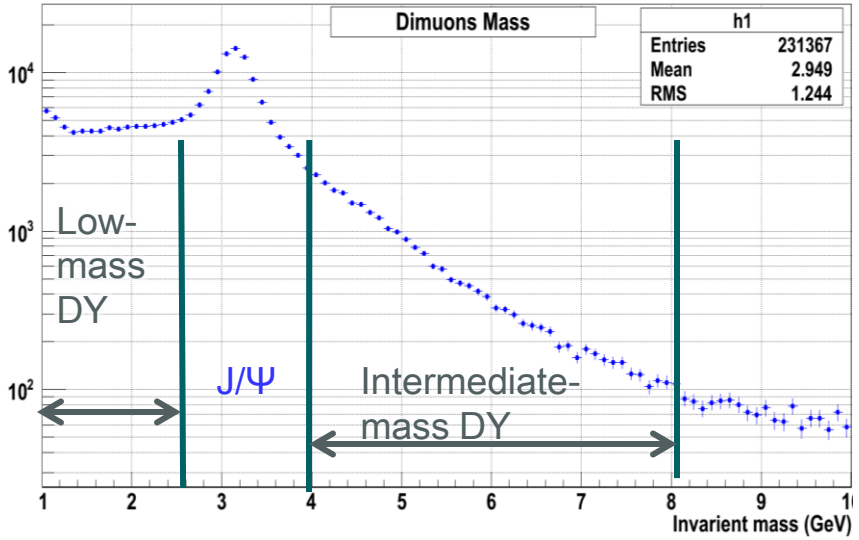


Intermediate-mass Drell-Yan

- The Drell-Yan process between 4 GeV < M < 8 GeV of invariant mass is called Intermediate-mass Drell-Yan process
- The PHENIX FVTX can help to reduce the dominant background from beauty decays
- Prompt muons from DY
- Displaced tracks from heavy quark decays

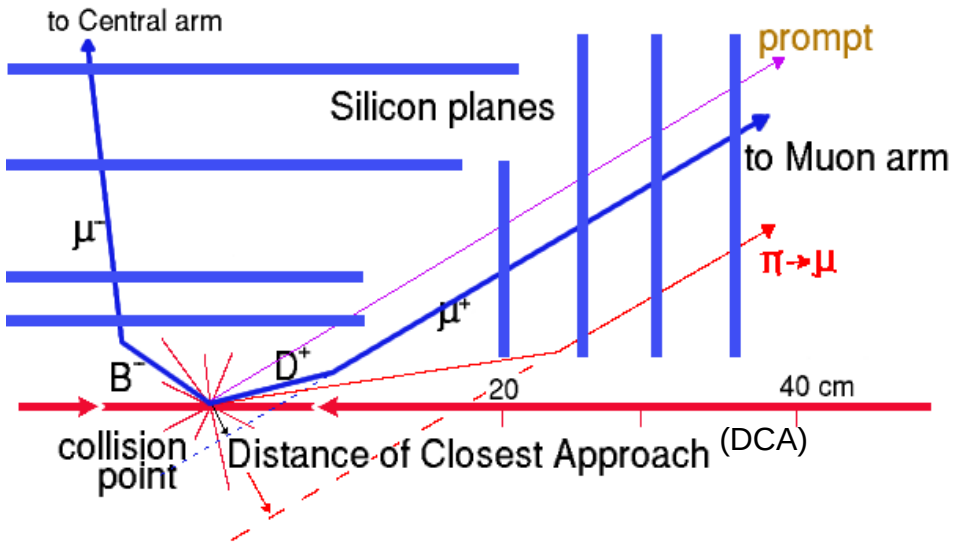


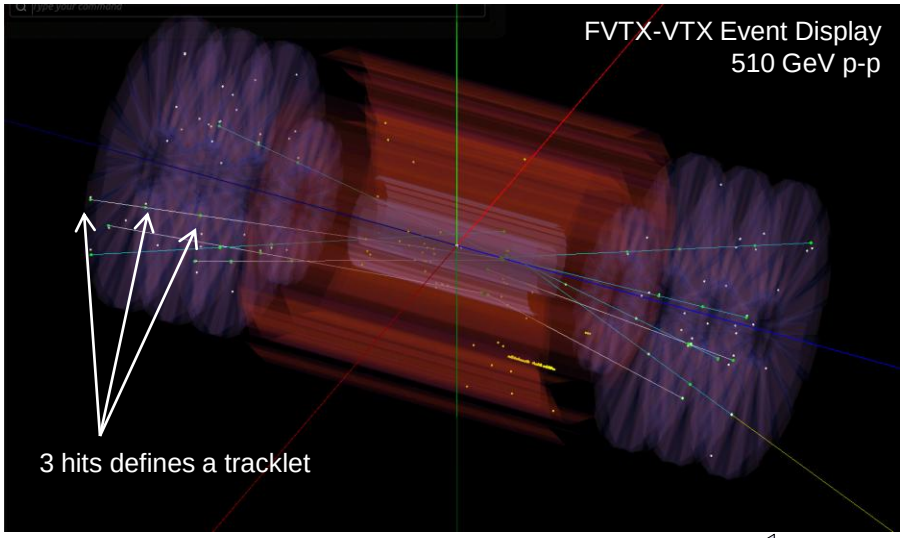
Simulation for p-p √s = 200 GeV(from the study for muon arm)

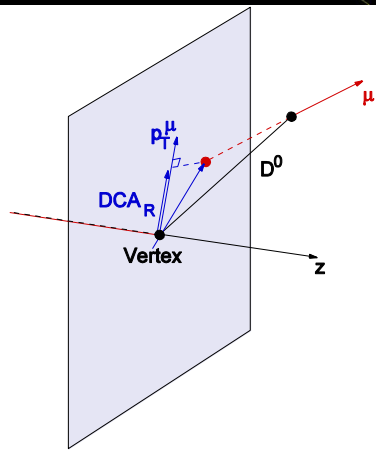


p-p √s = 510 GeV Run12 data

Extracting DY signal using FVTX

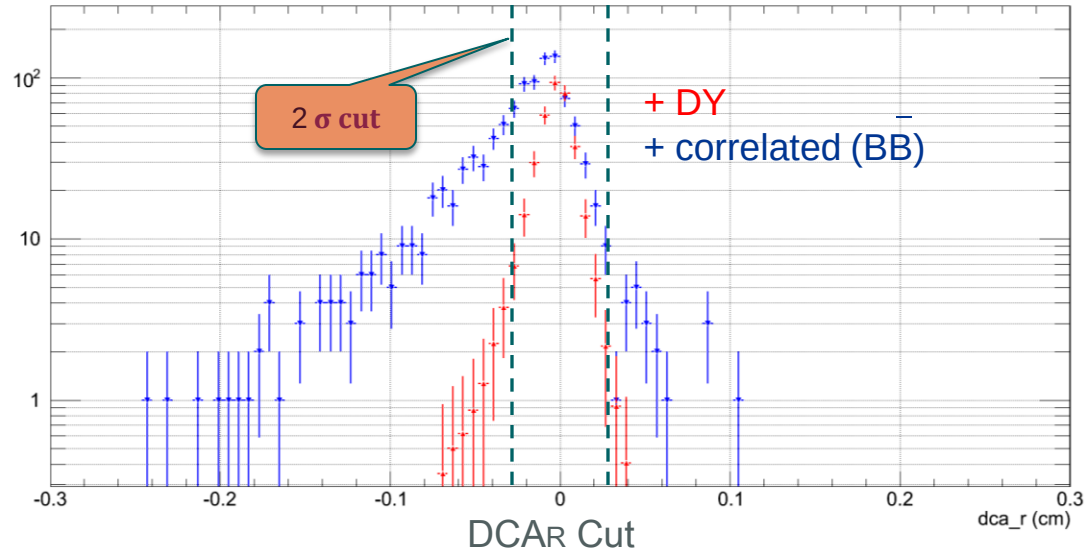


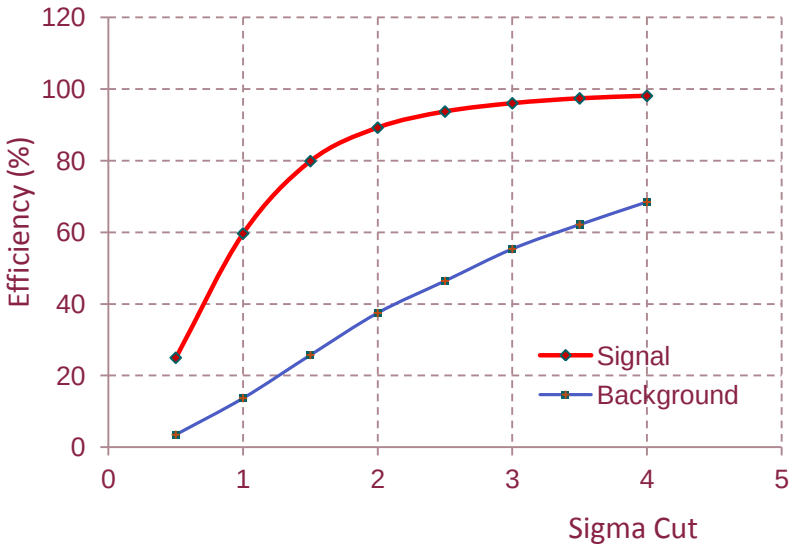




- Differentiate primary vertex from secondary decay using DCA
  - DCA cuts improve DY signal-to-background
- Comparison of the overall tracklet activity
- Isolation Cut
  - Cone Cut

Extracting DY signal with FVTX-DCA cuts

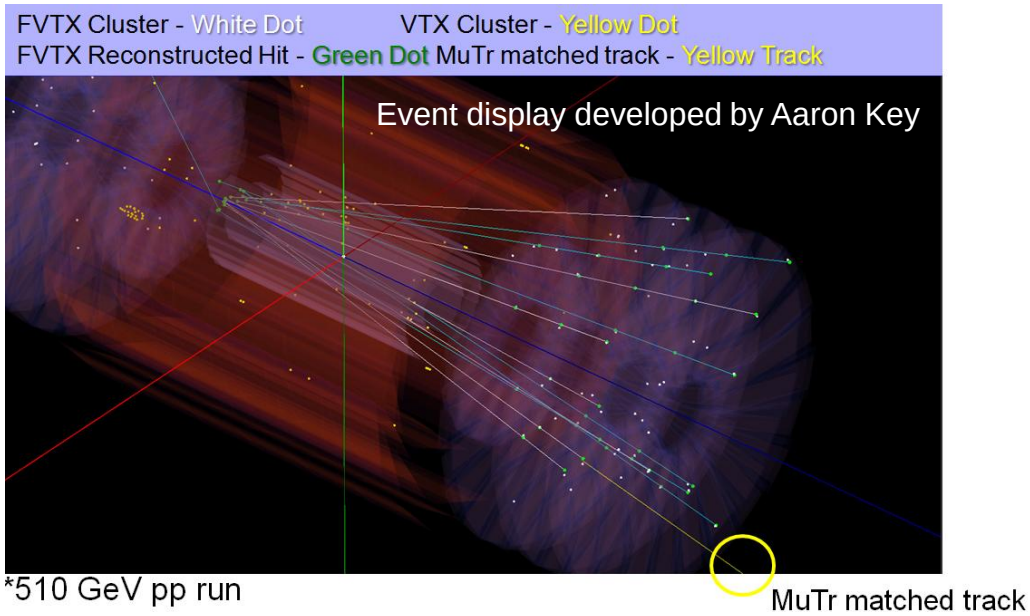


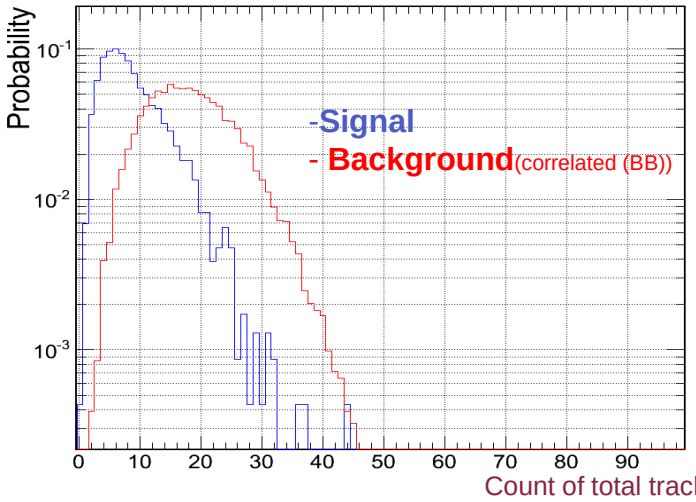


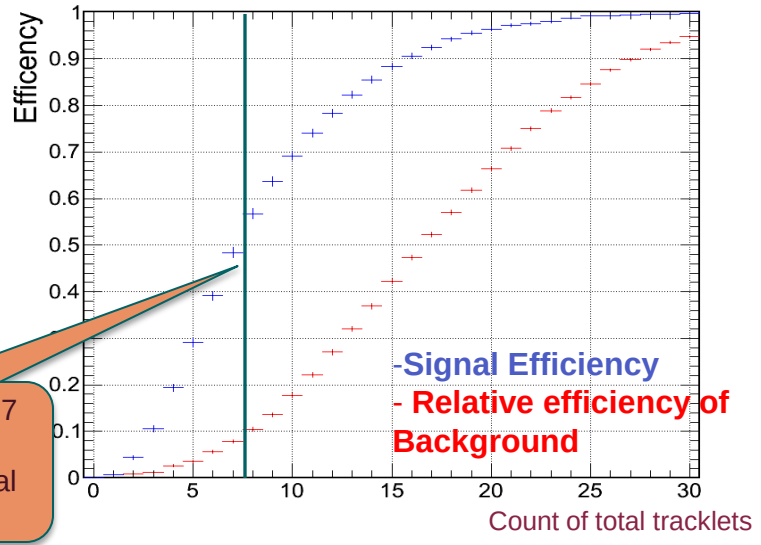
	Signal	Background
1 σ cut	60%	13%
2 σ cut	89%	37%
3 σ cut	96%	55%

- **DCAR cuts improve DY signal-to-background ratio. (dominated by beauty in intermediate mass region)**

Extracting DY signal with FVTX tracklet count







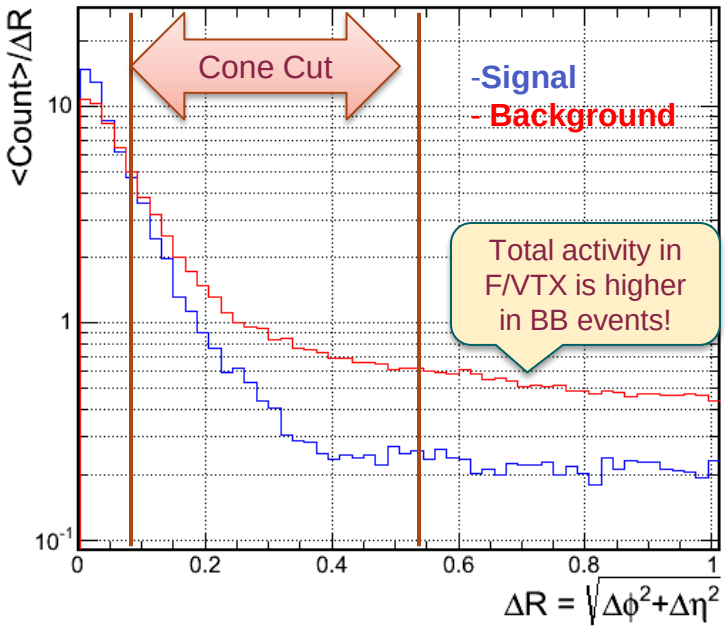
- **Compare the overall tracklet activity |z|<10cm**
- **Provides approximately a 10:1 rejection at 50% signal efficiency**

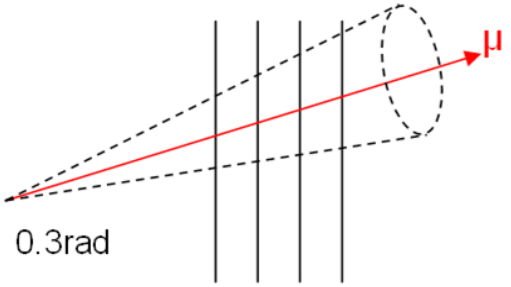
~10:1 rejection at 7 tracklets where there is 50% signal efficiency

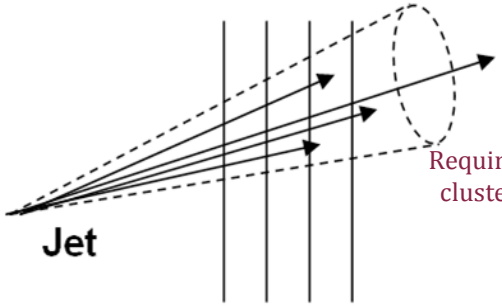
Plotted by Jin Huang and Cesar Luiz da Silva

Extracting DY signal with FVTX Isolation Cut

- **Three ways implemented in the cone isolation study**
  - Tracklet-based – best quality, but lowest stat
  - Cluster-based – highest stat., but vulnerable to background
  - Cluster-pair based – a balance of both
- **$dR = sqrt(d\eta^2 + d\varphi^2)$**
  - Bin separated in logarithmic scale 0.01 – 1 rad







Require that a track have limited clusters/hits around it.

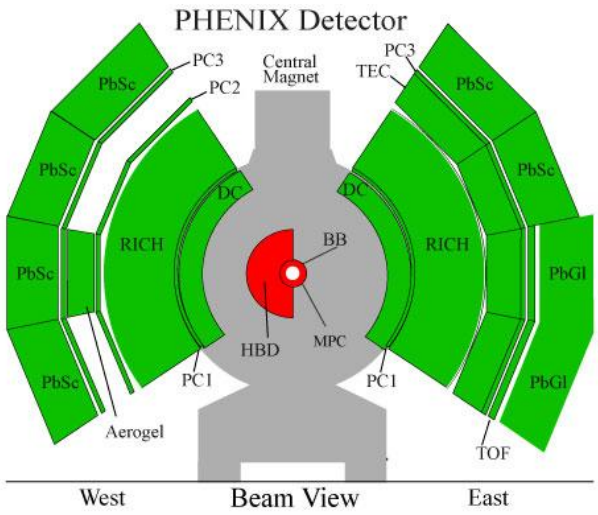
Plotted by Jin Huang and Cesar Luiz da Silva

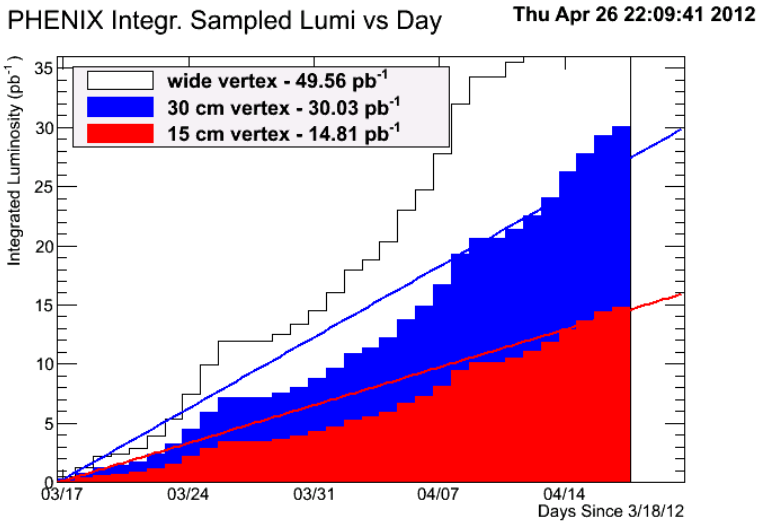
Summary

- The main background for Drell-Yan signal is correlated BB and CC
- PHENIX muon arms have been recently upgraded and FVTX will significantly reduce backgrounds while having high efficiency on the signals
- The following methods show promising signs for isolating the Drell-Yan Signal
  - DCA Cut
  - Tracklet count
  - Isolation Cut
    - Cone Cut
- Statistical methods such as like sign subtraction will be used to remove other backgrounds like combinatorial background

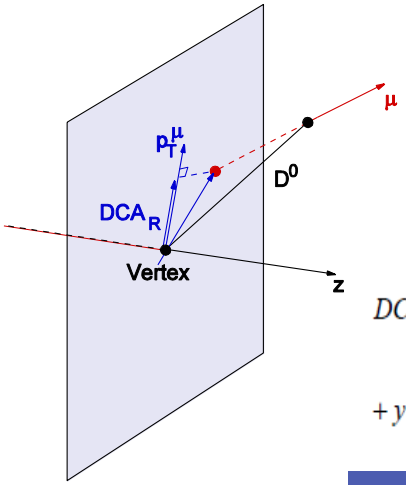
Thank you …!!!

Back up





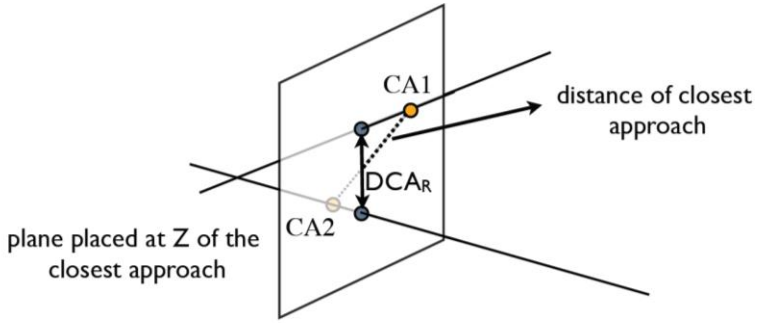
DCA_R Definition



DCA_R(Distance of Closest Approach) = impact parameter projected onto μ p_T.

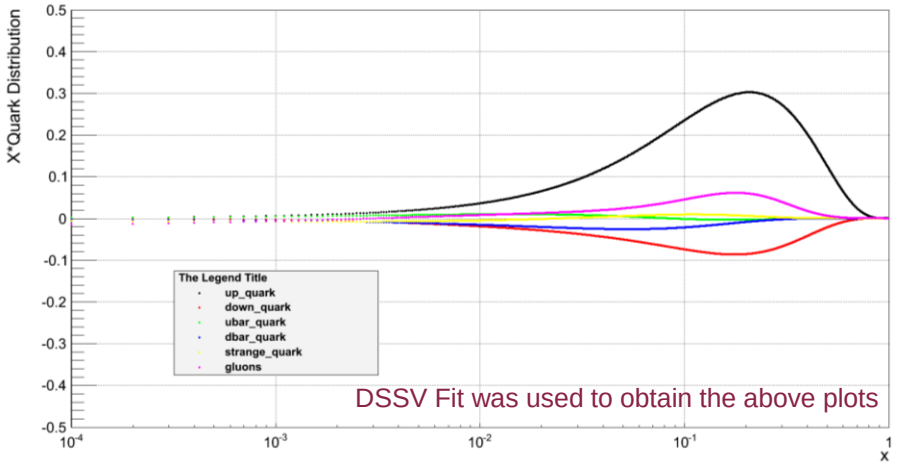
$$DCA_R = x0reco * \left(\frac{px0reco}{\sqrt{px0reco^2 + py0reco^2}}\right) + y0reco * \left(\frac{py0reco}{\sqrt{px0reco^2 + py0reco^2}}\right);$$

New definition for dimuon DCA_R



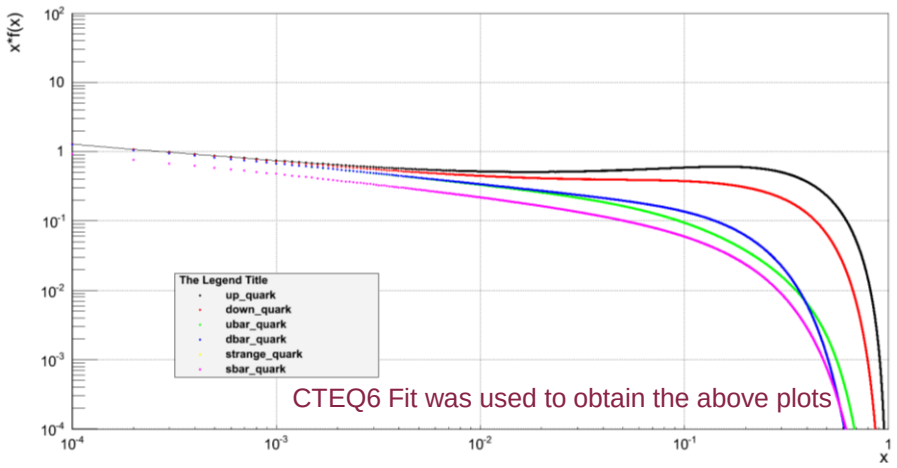
Back up

Polarized Quark Distributions

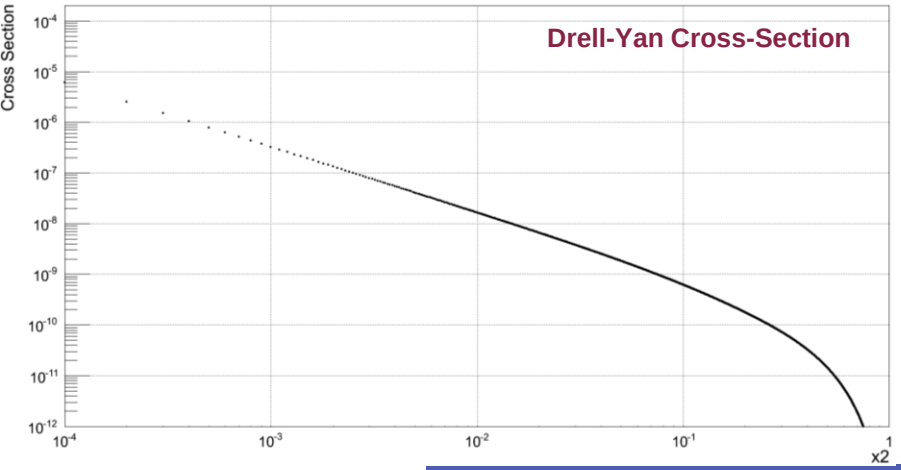


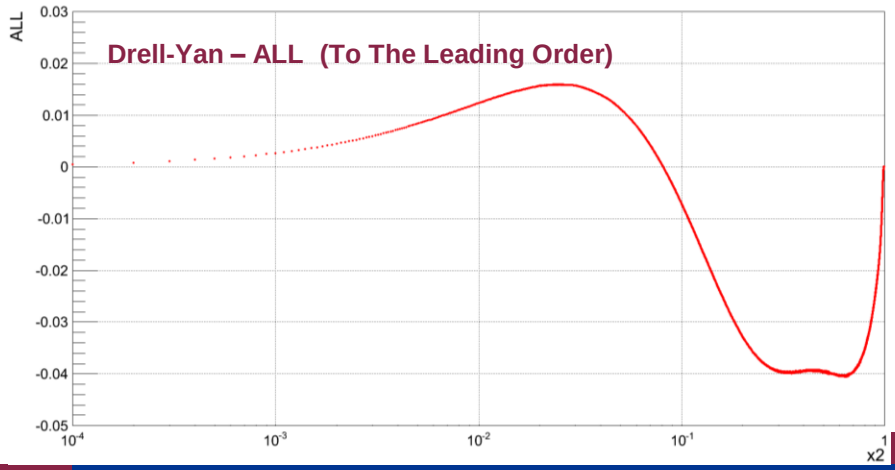
DSSV Fit was used to obtain the above plots

Unpolarized Quark Distributions



CTEQ6 Fit was used to obtain the above plots





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